Astrophysical Reaction Rates calculation using ENDF/B, JEFF and JENDL libraries

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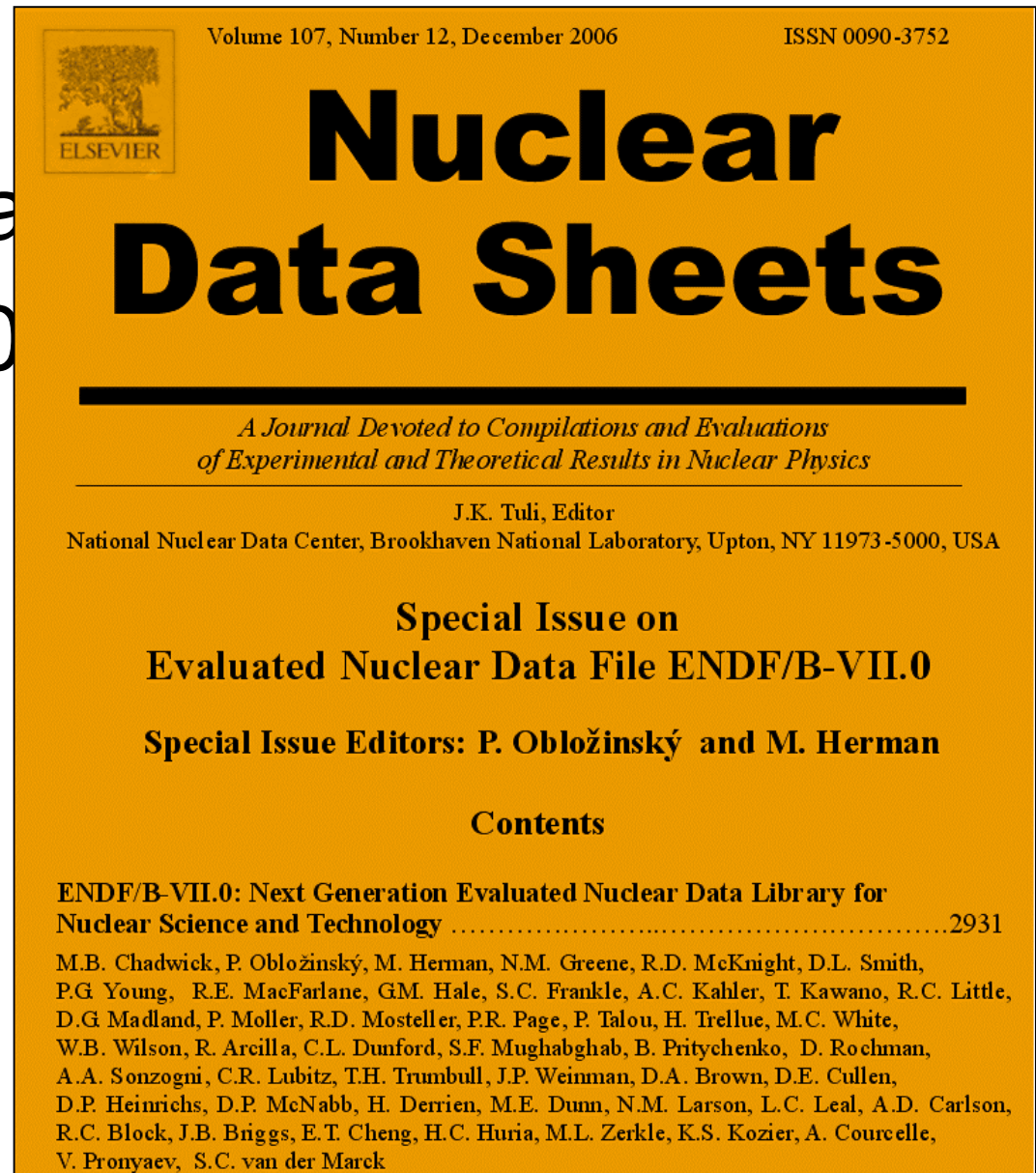Brookhaven National Laboratory*

*Email: pritychenko@bnl.gov

Evaluated Neutron Libraries

❑ Nuclear Data activities started at BNL in 1951 with neutron compilations

❑ BNL-325 (Atlas of Neutron Resonances) & ENDF (Evaluated Nuclear Data File)

❑ Evaluated Nuclear Data File is covering all nuclides of practical relevance for neutrons from 10^{-5} eV up to 20 MeV

❑ Four major evaluated neutron libraries: ENDF/B-VII.0, JEFF-3.1, JENDL-3.3 and ENDF/B-VI.8

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ENDF/B-VII.0

□ ENDF/B-VII.0 libra

December 15, 200

Volume 107, Number 12, December 2006   ISSN 0090-3752

ELSEVIER

Nuclear Data Sheets

A Journal Devoted to Compilations and Evaluations
of Experimental and Theoretical Results in Nuclear Physics

J.K. Tuli, Editor
National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973-5000, USA

Special Issue on
Evaluated Nuclear Data File ENDF/B-VII.0

Special Issue Editors: P. Obložinský and M. Herman

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NIF Nuclear Astrophysics Workshop,
Livermore, August 27 - 30 2007

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ENDF/B-VII.0 Astrophysical Applications

- ❑ 393 neutron reaction data evaluations in ENDF/B-VII.0 vs. 337 in JENDL-3.3

- ❑ 251 out of 286 nuclides (87.7%) from solar nuclide abundances paper of E. Anders & N. Grevesse, (s-process nuclei)

- ❑ 3838 nuclei in radioactive decay data sublibrary

Project Motivation

☐ ENDF keV region data are attractive for nuclear astro̲...̲

☐ JENDL-3.3 c̲... not always ag̲... Bao et *al*.

☐ Calculate 4 n̲... under the sar̲...

☐ Complimenta̲...

☐ Load results ̲...

(http://www.nndc.bnl.gov/sigma)

NNDC National Nuclear Data Center

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Home

NNDC Databases: NuDat | NSR | XUNDL | ENSDF | MIRD | ENDF | CSISRS | CINDA

Retrieval SigmA Plotting

CSEWG Evaluated Nuclear Data File (ENDF) ENDF B-VII.0

| Periodic Table Browse | Directory Tree Browse | Basic Retrieval | Advanced Retrieval | Plot Cart |

Select first a library, then a sublibrary and finally click on a chemical element to obtain results.
Data is available for materials with a cyan background.

Library: ENDF/B-VII.0 (USA, 2006)   Sublibrary: Neutron reactions

Results for Z=3

ENDF-6 format   Human-readable

Whole file -
introduction   Interpreted
res. param.   Interpreted
Cross sections:
(n,total)   Interpreted   Plot
(n,elastic)   Interpreted   Plot
(n,non-elastic)   Interpreted   Plot
(n,inelastic)   Interpreted   Plot
(n,2nα)   Interpreted   Plot
(n,n'ₖ) (click to expand)
(n,γ)   Interpreted   Plot
(n,p)   Interpreted   Plot
(n,t)   Interpreted   Plot
Angular distributions:
(n,elastic)   Interpreted
(n,2nα)   Interpreted
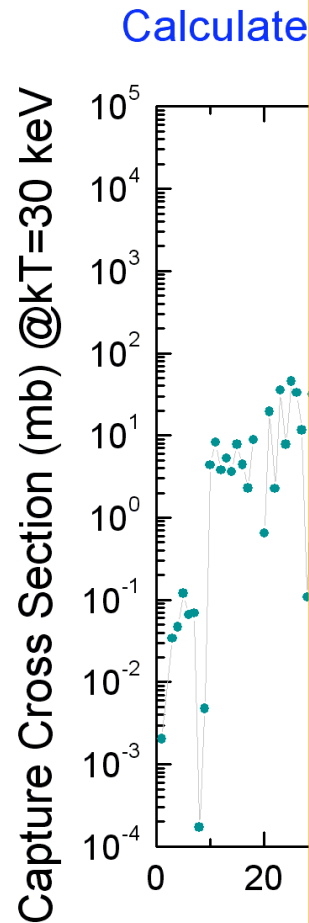(n,n'ₖ) (click to expand)
Energy distributions:

Database Manager: *Mike Herman, NNDC, Brookhaven National Laboratory*
Web and Programming: *B. Pritychenko, A.A. Sonzogni, NNDC, Brookhaven National Laboratory*

Data Source: *CSEWG* and *NEA-WPEC*

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Maxwellian Cross Sections (MACS)

❑ Java Simpson numerical integration

   of JE

   Nak

❑ Con

Calculate

ENDF/B-VII.0 MACS vs. Bao et *al*., ANDT 76 (2000) 70

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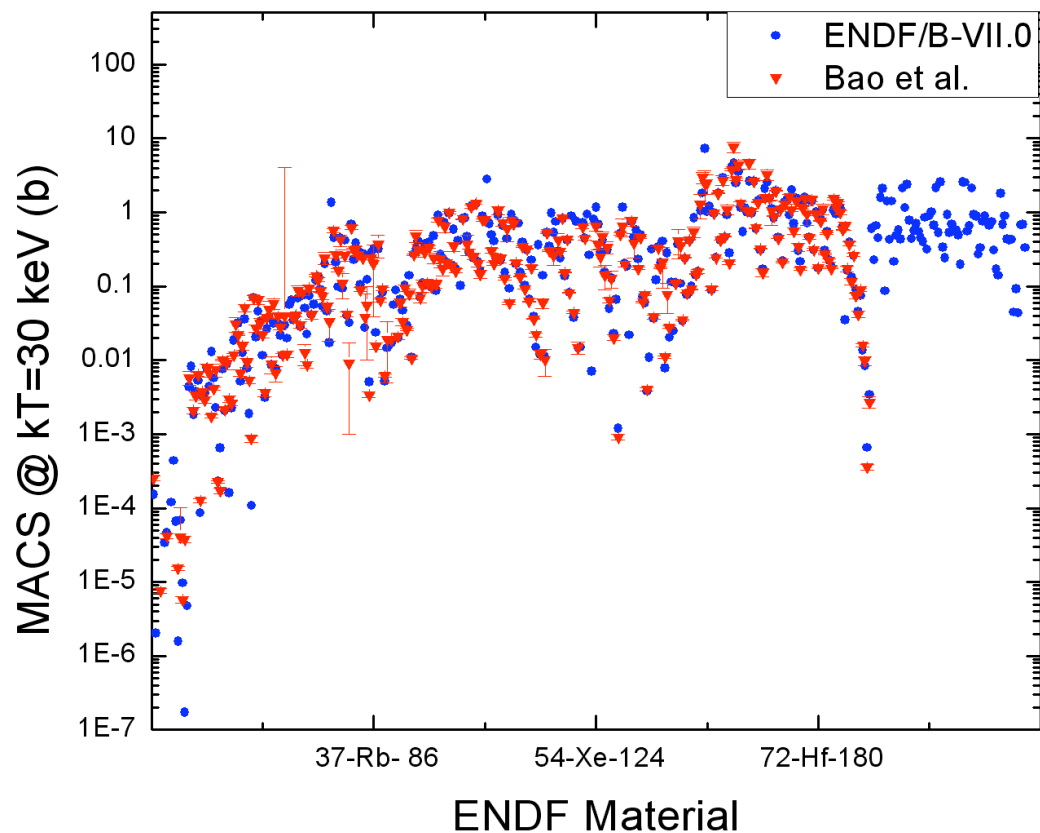
Reaction Rates

- ❑ Reactio...
  compar...
- ❑ Product
  abunda...
- ❑ σN ratio
  - ✓ ENDF/E...
  - ✓ JEFF-3...
  - ✓ JENDL...
  - ✓ ENDF/E...
  - ✓ Bao et
- ❑ Covariances =>
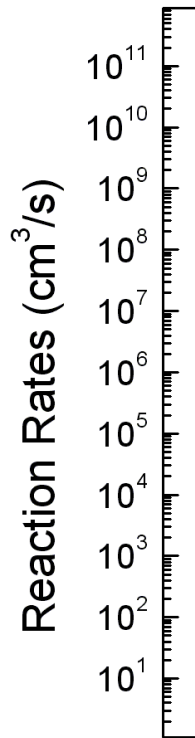
Astrophysical Reaction Rates, kT=30 keV

Reaction Rates (cm³/s)

10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}

Neutron Cross Sections (30 keV) x Solar Abundances

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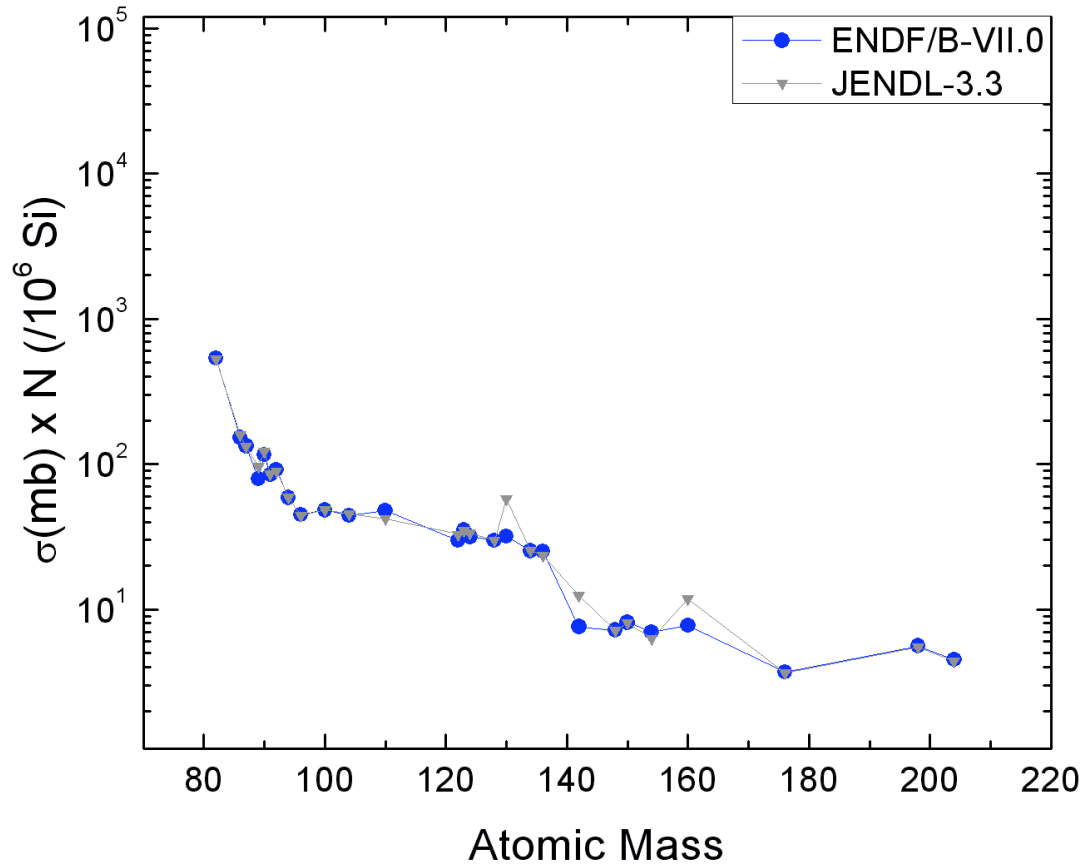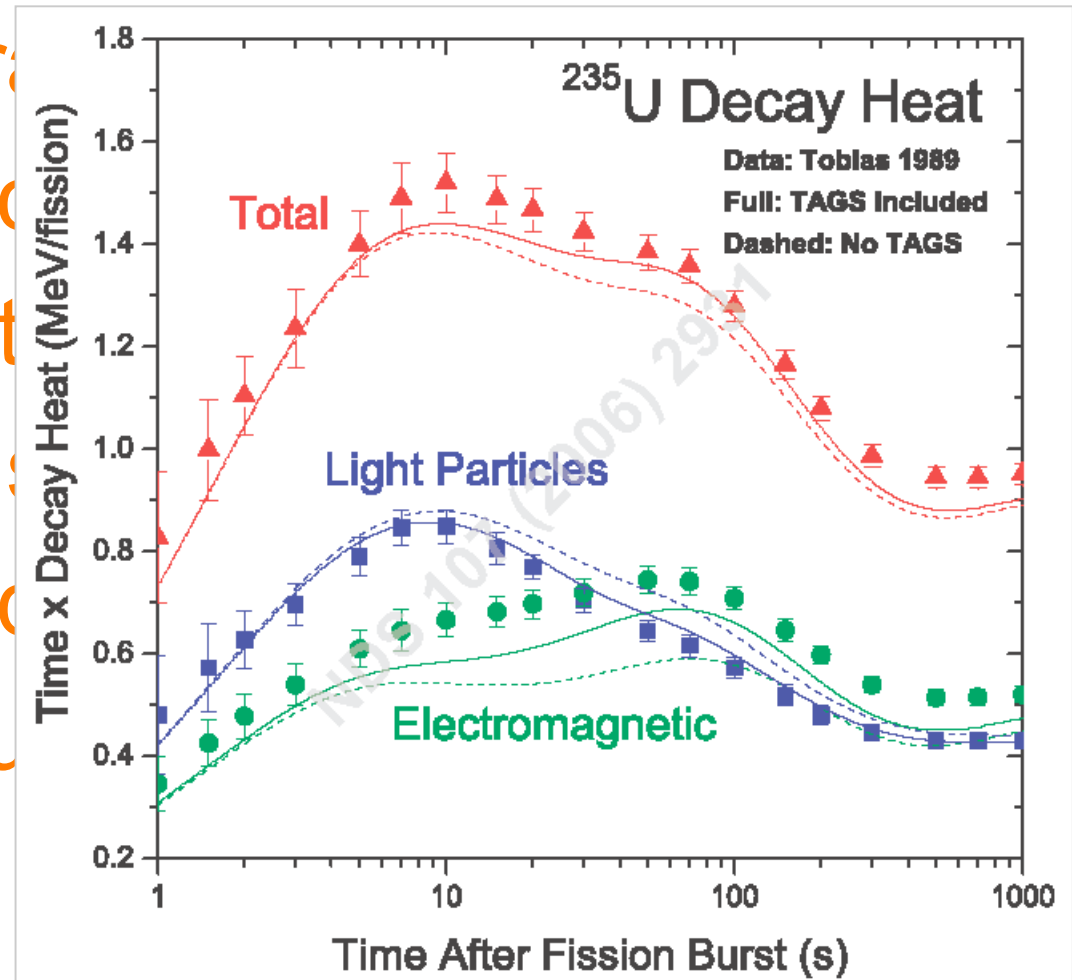
Future Work I

An example related to NIF: Consecutive neutron capture on ^{197}Au along *s*-process path

- ❑ ENDF: ^{197}Au, $^{198-202,20...}$
- ❑ EMPIRE (M. Herman... nuclides of Au, Hg, T...
- ❑ MACS and reaction r... Maxwellian neutron e...

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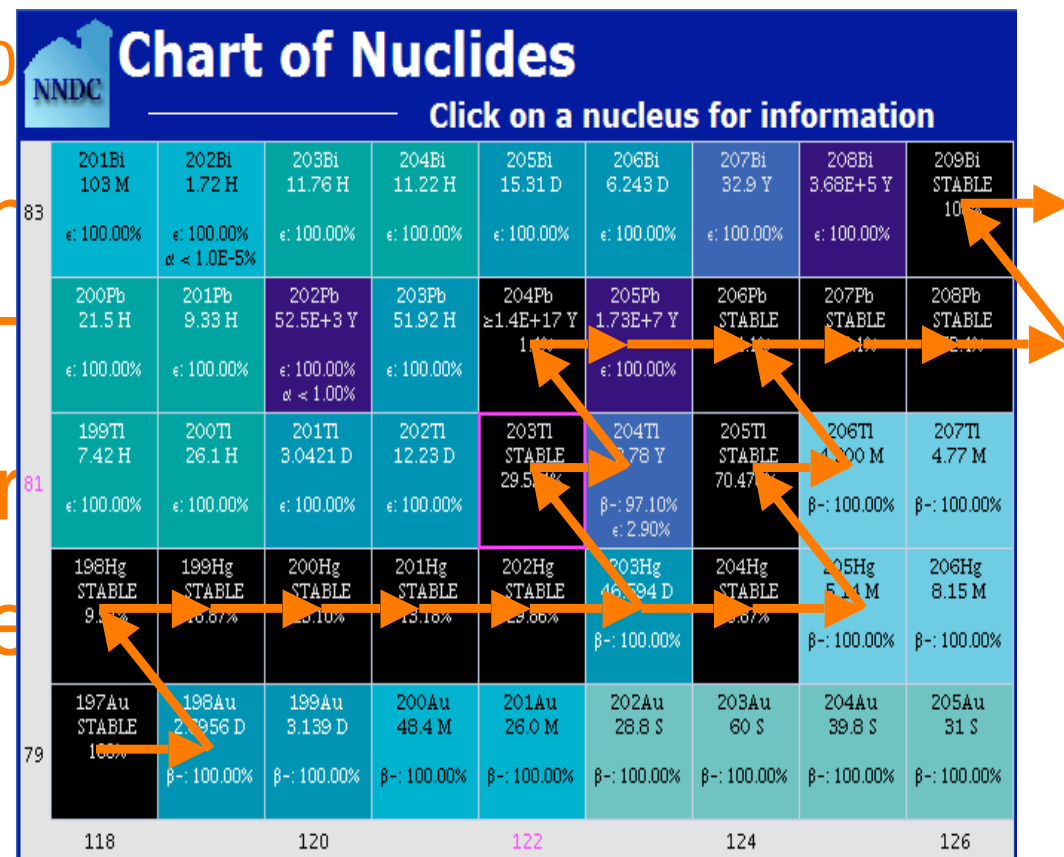
Future Work II

❑ **Practical application of a brand new**

decay data sublibra

decay network calc

❑ **Sublibrary was opt**

energy applications

❑ **It can be expanded**

❑ **An example of neu**

^{235}U Decay Heat

Data: Tobias 1989
Full: TAGS Included
Dashed: No TAGS

Total

Light Particles

Electromagnetic

NDS 107 (2006) 2931

Time x Decay Heat (MeV/fission)

Time After Fission Burst (s)

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Conclusion & Outlook

❑ (n,γ), (n,α), (n,f), $(n,2n)$, (n,p), $(n,t2\alpha)$ Maxwellian cross sections and reaction rates have been calculated using four major libraries: ENDF/B-VII.0, JEFF-3.1, JENDL-3.3, ENDF/B-VI.8

❑ Results are compared with:
  ❑ JENDL-3.3 calculations of T. Nakagawa et *al*. ADNDT 91 (2005) 77
  ❑ Bao et *al*., Rauscher & Thielemann
  ❑ Neutron cross sections x Solar system abundances

❑ Results will be loaded into Sigma database (http://www.nndc.bnl.gov/sigma) and published

❑ Future work may include reaction rates and MACS for NIF

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